

A Status Report on the TEAM Project

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Recent developments in aberration-correcting electron optics have created the opportunity to directly observe the atomic-scale order, electronic structure, and dynamics of individual nanoscale structures by advanced transmission electron microscopy. To take advantage of this opportunity, the TEAM project brings together five leading microscopy groups supported by the US Department of Energy's Office of Science to jointly design and construct a new generation microscope with extraordinary capabilities. The project is part of DOE's 20-year roadmap of Facilities for the Future of Science [1], and after its completion in 2009, the instrument will be made available to the scientific user community at the National Center for Electron Microscopy.

The vision for the TEAM project is the idea of providing a sample space for electron scattering experiments in a tunable electron optical environment by removing some of the constraints that have limited electron microscopy until now. The resulting improvements in spatial, spectral and temporal resolution, the increased space around the sample, and the possibility of exotic electron-optical settings will enable new types of experiments. The TEAM microscope will feature unique corrector elements for spherical and chromatic aberrations, a novel AFM-inspired specimen stage, a high-brightness gun and numerous other innovations that will extend resolution down to the half-Angstrom level. The improvement in sensitivity, brightness, signal to noise and stability will make it possible to address major challenges such as single atom spectroscopy and atomic resolution tomography.

The machine is being designed as a platform for a sequence of instruments, each optimized for different performance goals that have been identified in a series of workshops [2]. The most important scientific driving force that emerged from these workshops is the need for in-situ experiments to observe directly the relationship between structure and properties of individual nanoscale objects. Extensive input from the scientific community has helped shape the direction of the project, whose primary driving force has been the scientific goal to probe nanoscale volumes of materials with atomic resolution. The TEAM proposal has been discussed in a series of workshops at ANL (2000), LBNL (2002), M&M San Antonio (2003), M&M Savannah (2004) and M&M Honolulu (2005) [2], and the project is guided by a Scientific Advisory Committee [3].

The partner labs collaborating in this project are shown in Figure 1, and a time line of events is given in Figure 2. The TEAM instrument will be installed at the National Center for Electron Microscopy in 2009 and will be operated as a user facility to support the growing need for atomic-scale characterization in the nanoscience community. Its origin in the needs of nanoscience has imposed a set of important constraints on the project in terms of timing, goals and approach. To maximize the impact on the DOE nanoscience centers at LBNL, ANL, ORNL and BNL, an initial instrument (TEAM 0.5, without Cc correction) is scheduled to become operational in 2008. A call for proposals will be issued several months prior to start of operations.

To be able to address materials issues across disciplines, the machine will be designed to operate between 80 and 300kV. Aberration correction for the probe and the image will allow 0.5Å resolution in both, the STEM and TEM modes. On the final TEAM I instrument (see timeline) a post-specimen corrector will correct for spherical as well as chromatic aberration. A novel 5-axis piezoceramic stage will provide precise control over sample position and tilt, facilitating data collection for high-resolution tomography. A 5-mm pole-piece gap will provide sufficient space for in-situ experiments and high tilt angles for tomography. The instrument will include a monochromator for 0.1eV energy resolution as well as an imaging energy filter.

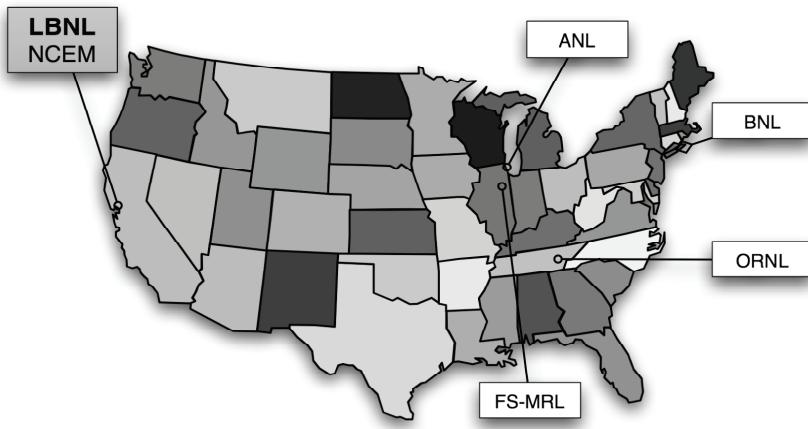


FIG.1 – Geographic distribution of the five DOE TEAM partner labs in the US.

integration and will work with CEOS on development and implementation of aberration correctors. As a DOE project, TEAM is subject to a very stringent set of rules that impose strict reporting requirements with great emphasis on adherence to timelines and budgets.

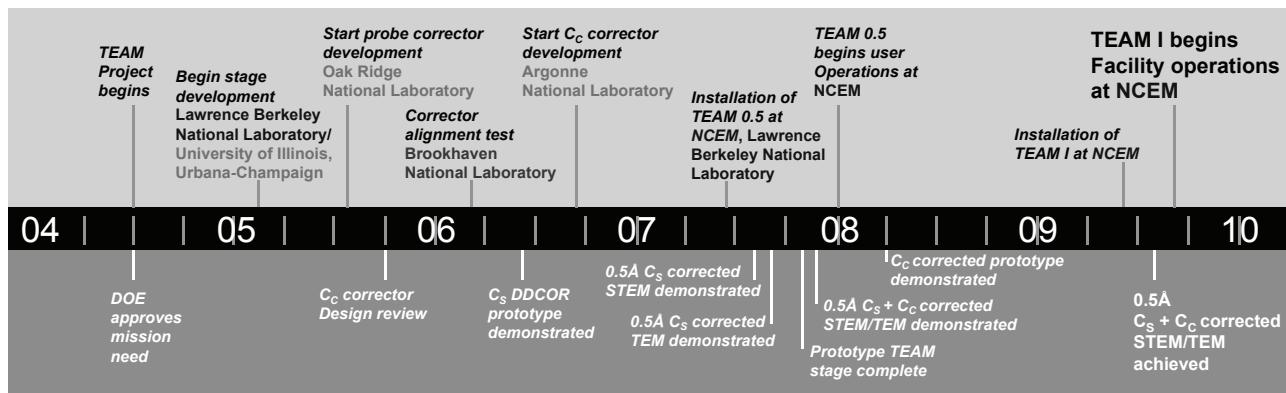


FIG.2 – Timeline for significant steps in the TEAM project showing involvement of the DOE partner labs.

This talk will give an overview of the TEAM collaboration with its scientific and technical goals, and present status report on technical developments to provide information about capabilities of the TEAM instrument in preparation for the initial call for proposals to the user community [4].

References

- [1] <http://www.er.doe.gov/about/Future/Facilities%20for%20the%20Future%20of%20Science.htm>
- [2] Reports from these workshops and more information on the TEAM project can be found at <http://ncem.lbl.gov/team3.htm>
- [3] TEAM investigators: U. Dahmen, A. Minor, C. Kisielowski, M. Watanabe, A. Schmid - (LBNL), D. Miller, B. Kabius, N. Zaluzec - (ANL), Y. Zhu, J. Wall - (BNL), I. Petrov, I. Robertson, J.M. Zuo - (FS-MRL), E. Kenik, J. Bentley, S. Pennycook - (ORNL)
- [4] C.B. Carter, A. Eades, J. Silcox, J. Spence and R. Tromp
- [5] The TEAM project is supported by the Director, Office of Science, Office of Basic Energy Sciences, Division of Materials Sciences and Engineering, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

The partner labs are working together in a collaborative mode that reflects the significance of aberration correction for all segments of the microscopy community. Each of the partner labs is responsible for delivery of a particular component, technique or expertise needed for the TEAM instrument (see timeline). Several of the sub-tasks involve operation of a test column for a period of time to shake down, align, optimize and integrate different components. Based on detailed analysis and discussion, the collaboration has selected FEI as the major partner for column